

CLAIMS

1. A method for generating extreme ultraviolet (EUV) or soft X-ray radiation wherein a plasma is generated and heated in a hybrid manner by the combination of a laser radiation produced by a laser source which is focused to intensities beyond 10^6W/cm^2 onto a target and of an electric discharge produced by electrodes combined with means for producing a rapid electric discharge, wherein the time constant of the laser produced plasma expansion time exceeds the characteristic time constant of the discharge.

2. A method according to claim 1, wherein the target is a gaseous, liquid, liquid spray, cluster spray or solid medium, such as a bulk or foil target, more than $10^{19} \text{ atoms/cm}^3$.

3. A method according to claim 1 or claim 2, wherein a EUV plasma is first produced by the laser radiation focused on a dense target in a laser interaction zone and subsequently a discharge is induced across the laser interaction zone thereby boosting the initial laser produced plasma and enhancing total EUV light production.

4. A method according to claim 1 or claim 2, wherein a cold plasma is generated by the laser radiation focused on the target to produce a cold plasma plume and a discharge is then actively triggered in a delocalised interaction zone of the plasma plume to heat and compress the plasma for more confined EUV light emission.

5. A method according to anyone of claims 1 to 4, wherein the current pulses that are applied in the presence of plasma by the electrodes are provided by the rapid discharge of capacity stored energy.

6. A method according to anyone of claims 1 to 5, wherein the current pulses that are applied in the presence of plasma by the electrodes are selected with a period within a one-to-three digit nanosecond range.

7. A method according to anyone of claims 1 to 6, wherein the current pulses that are applied in the presence of plasma by the electrodes are selected with amplitudes in a two-to-three digit kilo-ampere range.

35 8. A method according to anyone of claims 1 to 7, wherein the current pulses that are applied in the presence of plasma by the

electrodes are switched in a defined temporal relation with the firing of the laser pulses produced by the laser source.

9. A method according to anyone of claims 1 to 8, wherein the plasma produced has a temperature in the six-digit Kelvin range.

5 10. A method according to anyone of claims 1 to 9, wherein the plasma is generated with gas pressures selected in the range below 10 Pa.

11. A method according to anyone of claims 1 to 10, wherein the plasma emits radiation with wavelengths shorter than 50 nm.

12. A method according to anyone of claims 1 to 11, wherein 10 the target is chosen from the following materials : xenon, tin, copper, lithium, oxygen, iodine.

13. A device for generating extreme ultraviolet (EUV) or soft X-ray radiation wherein it comprises a laser source for producing a laser radiation which is focused to intensities beyond 10^6 W/cm² onto a target 15 to produce a plasma, electrodes located around the path of the plasma produced by the laser source, the electrodes being combined with means for producing a rapid electric discharge in the plasma with a characteristic time constant which is less than the time constant of the laser produced plasma expansion time.

20 14. A device according to claim 13, wherein the means for applying electrical energy comprise a pulse compressor.

15. A device according to claim 13, wherein the means for storing electrical energy comprise a capacity bank.

25 16. A device according to claim 15, wherein the electrodes are connected directly to the capacity bank to produce said rapid electric discharge.

30 17. A device according to claim 15, wherein the electrodes are connected to the capacity bank through a power on-off switch which is switched on by a logic control element to produce said rapid electric discharge.

18. A device according to anyone of claims 13 to 17, wherein the discharge time between the electrodes is between 100 ns and 200 ns, whereas the laser pulse duration of the laser pulses generated by the laser source is a few nanoseconds and does not exceed 60 ns.

35 19. A device according to anyone of claims 13 to 18, wherein it comprises a nozzle for injecting a cold jet target, a micro-liquid jet, a

droplet spray target, a cluster jet target or an effusive gas target into a joint vacuum chamber equipped by at least one electrically insulating block to hold the electrodes around a laser interaction zone of the target.

20. A device according to claim 19, wherein the electrically
5 insulating block has a high thermal conductivity.

21. A device according to claim 20, wherein the electrically insulating block is cryogenically cooled and allows evacuating the head load produced by absorption of both unused in-band and out-of-band radiation.

10 22. A device according to claim 20 or claim 21, wherein the electrically insulating block also acts as a head shield for a cryogenic target injector.

15 23. A device according to anyone of claims 19 to 22, wherein it further comprises a second vacuum chamber that is connected to the first vacuum chamber via an orifice for receiving the unused target material downstream the EUV light emission zone.

24. A device according to anyone of claims 19 to 23, wherein the electrodes are arranged in either a Z-pinch, hollow cathode pinch, star pinch, or capillary discharge configuration.

20 25. A device according to anyone of claims 13 to 17, wherein the device comprises a laser source for producing a laser radiation which is focused to intensities beyond 10^6 W/cm² onto a dense target to produce a plasma.

25 26. A device according to anyone of claims 13 to 17, wherein a laser beam produced by the laser source irradiates a solid bulk, solid foil, liquid, spray, cluster or effusive gas target to produce a cold plasma plume and the discharging electrodes are arranged on the path of the plasma plume with the laser interaction zone, the discharging electrodes contributing to heat and compress the plasma for more confined EUV 30 emission.

27. A device according to claim 26, wherein it comprises a pulse generator connected to the electrodes that triggers an electrical discharge as the plasma plume enters the space between the electrodes.

35 28. A device according to anyone of claims 13 to 17, wherein it comprises discharging electrodes which are arranged next to a jet target to produce a high density plasma using a conventional discharge

configuration of a GDPP on the path of the plasma, a laser source which irradiates said plasma in a way which sustains the emission of EUV radiation, and a means to trigger the laser pulses when the pinch process makes the plasma dense enough to allow additional laser heating.